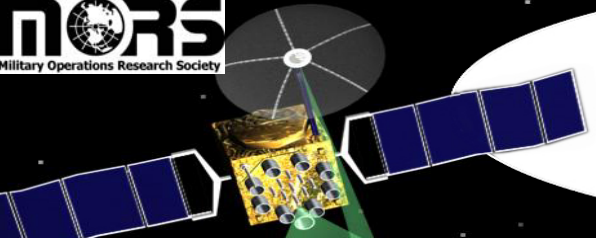

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21-23 June 2005, at US Military Academy, West Point, NY

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Name of Principal Author and all other author(s): Richard Bloser, Jeff Dubois

Principal Author's Organization and address:

Phone: (719)622-2857

Fax: (719) 597-7234

Email: rick.bloser@gd-ais.com

Original title on 712 A/B: Civil Position, Navigation, and Timing Analysis of Alternatives

Revised title: WG05BloserRichard.ppt

Presented in (input and Bold one): (WG 5 , CG___, Special Session ___, Poster, Demo, or Tutorial):

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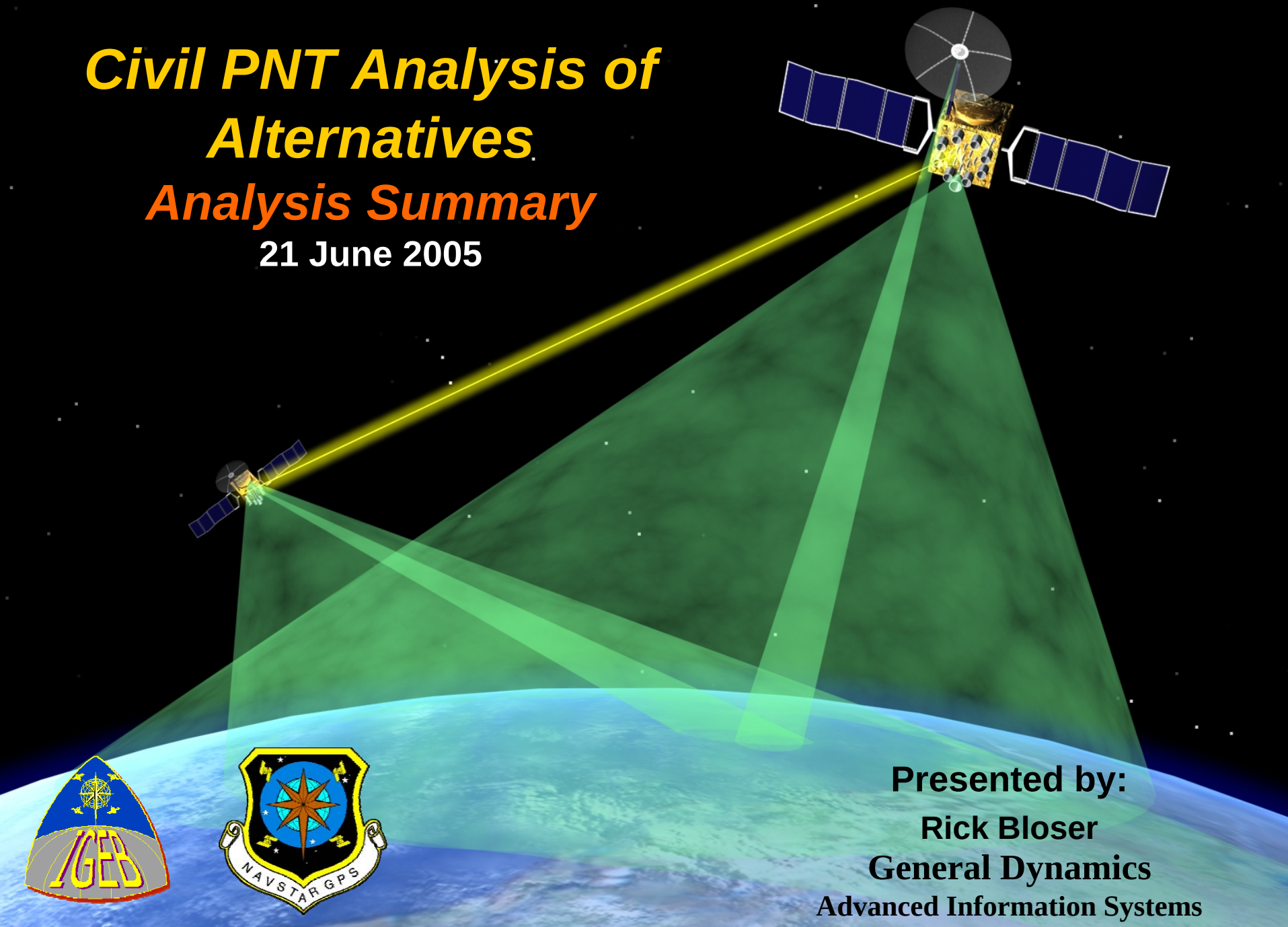
Civil PNT Analysis of Alternatives

Analysis Summary

21 June 2005



Presented by:

Rick Bloser

General Dynamics

Advanced Information Systems

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
30 SEP 2005	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Civil Position, Navigation, and Timing Analysis of Alternatives	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **General Dynamics Advanced Information Systems**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADM201946, Military Operations Research Society Symposium (73rd) Held in West Point, NY on 21-23 June 2005. , The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
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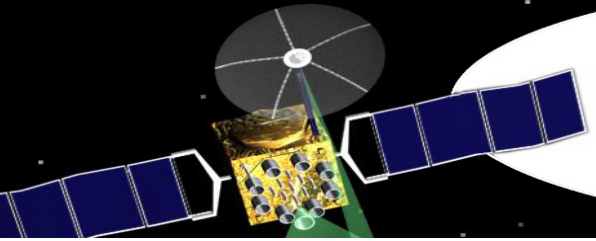
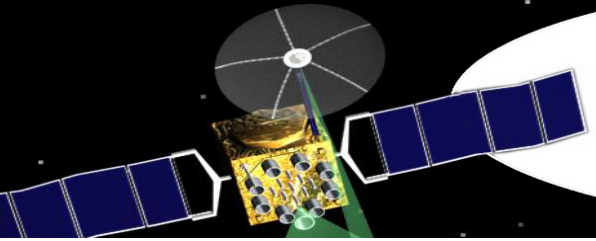


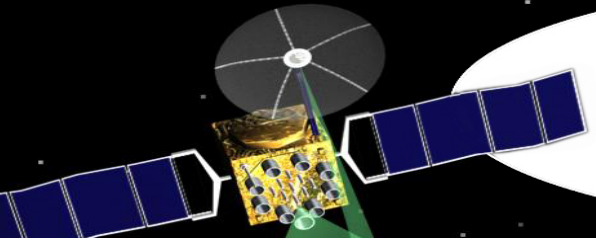
Purpose

- **Provide an overview of the Civil Position, Navigation, and Timing Analysis of Alternatives conducted for the IGEB. This presentation will discuss the analysis methods used, scenario analysis, and some of the challenges encountered in applying a military style AoA to an analysis conducted within the civil community.**



Agenda

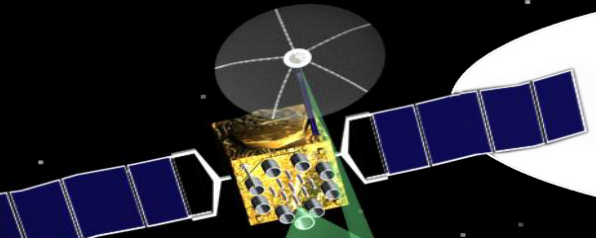
- **Background**
- Analysis Methodology
- Scenario Analysis
- Challenges



Civil PNT AoA Objectives

- **Conduct a Civil GPS Position, Navigation, and Timing (PNT) Analysis of Alternatives (AoA) to identify future GPS civil user requirements.**
  - **Analyze civil PNT requirements**
  - **Evaluate alternatives against requirements**
    - **Analyze the proper mix of GPS III improvements and augmentation systems supporting the various requirements.**
  - **Provide recommendations for potential inputs into the AFSPC requirements process and the Joint Program Office (JPO) development cycle to support civil requirements for GPS III**

Make a compelling statement for GPS civil user requirements and identify the most beneficial alternatives for the civil community



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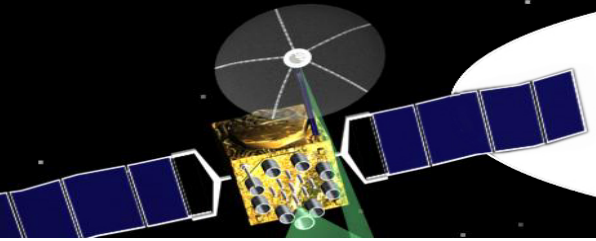


Strategy-to-Task* Hierarchy

- **Objective: Create a Functional Decomposition of National Strategy**

National Strategy

⬇

Operational Concepts

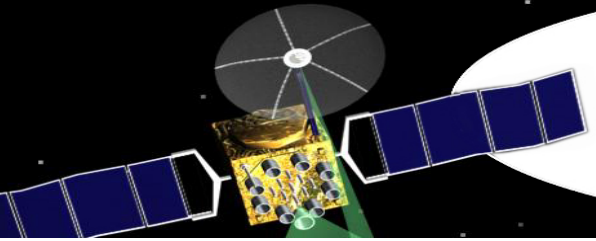
⬇

Mission Areas

⬇

Operational Tasks

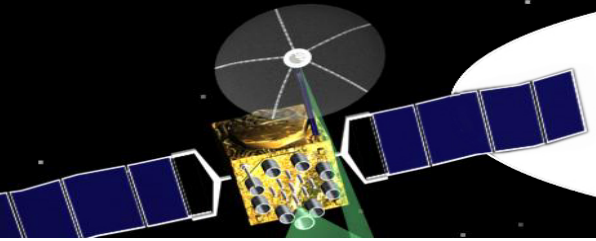
** Gen. Glenn A. Kent, "A Framework for Defense Planning", 1989*



Civil Strategy-to-Task* Hierarchy

- **Objective: Create a Functional Decomposition of Civil National / Industry Strategy**

National Strategy	National Programs/Industry
⬇	⬇
Operational Concepts	Regional/Company
⬇	⬇
Mission Areas	Service Applications
⬇	⬇
Operational Tasks	System Tasks

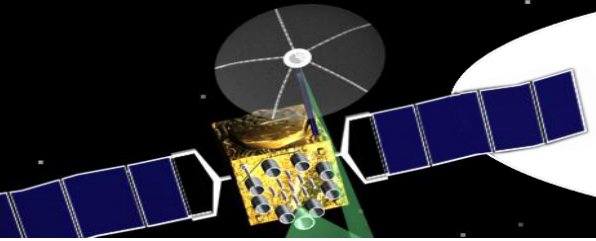


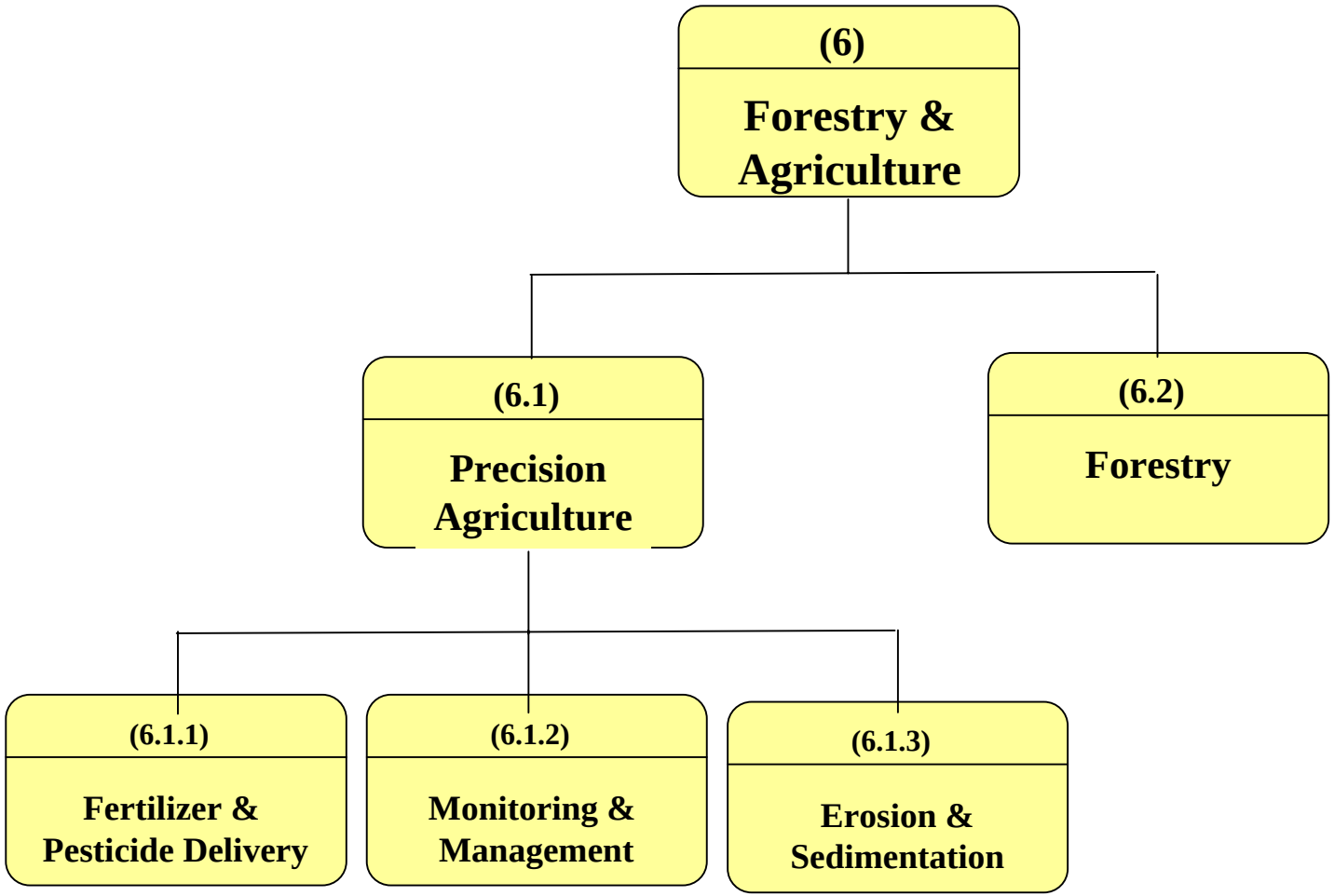
Scoping the Problem

- **Numerous GPS Civil Applications**
  - **National / Industry level applications**

1 **Aviation** FAA	**2** **Maritime and Waterways** DOT/USCG/NOAA	**3** **Ground Transportation** DOT/DOC
4 **Space** FAA/NASA	**5** **Communications and Timing** FCC/USNO/DOC/SEC	**6** **Forestry & Agriculture** USDA/DOI/DOC
7 **Public Safety & Services** DOJ/DOC/FEMA	**8** **Infrastructure** DOC/DOI/DOL	**9** **Environmental Studies** DOI/NOAA/EPA/FEMA

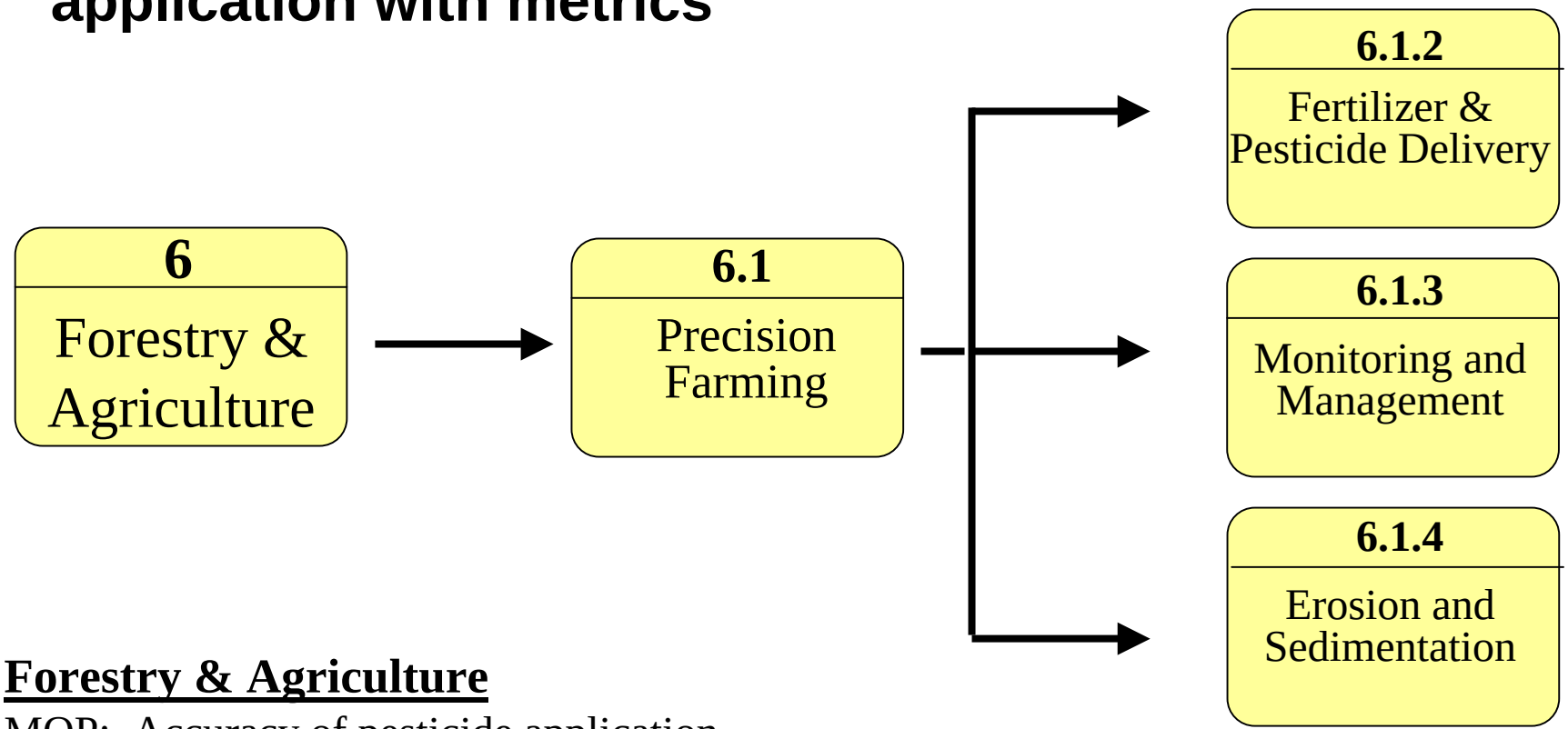
Decomposition of Forestry and Agriculture





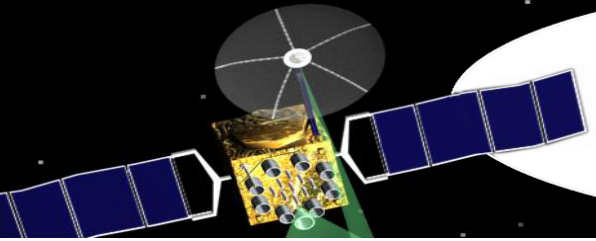
Decomposition with Metrics

- **Continued Decomposition of Forestry and Agriculture application with metrics**



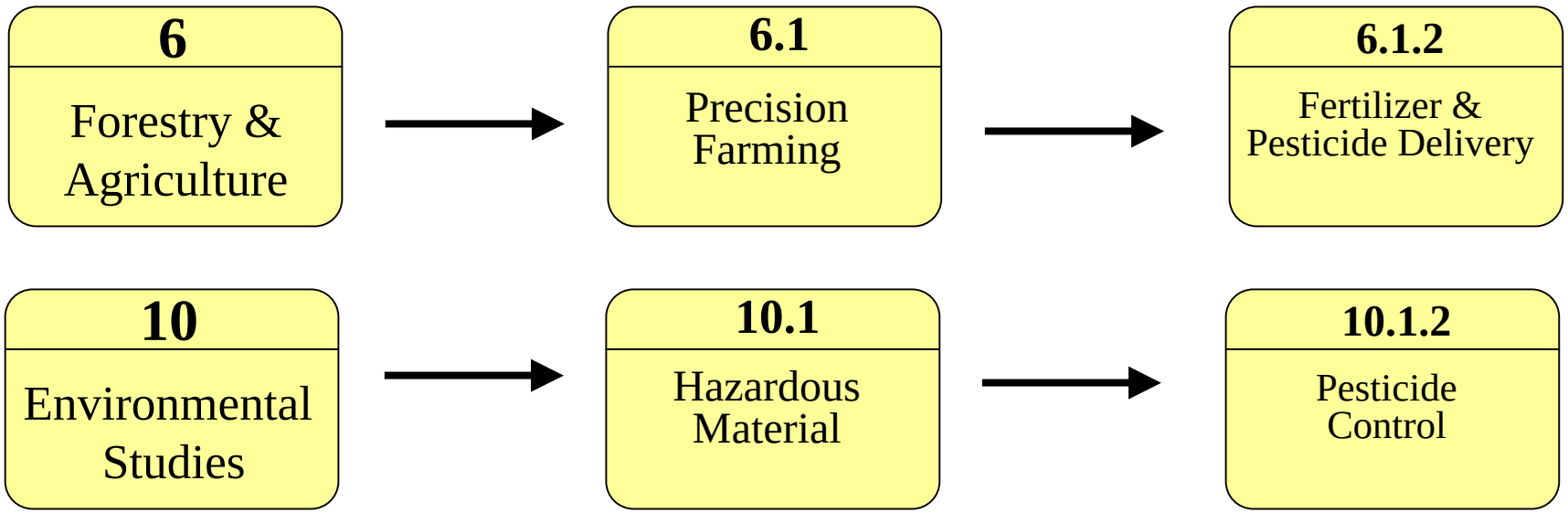
Forestry & Agriculture

MOP: Accuracy of pesticide application
MOE: Amount of pesticide used
MOO: Increase in crop yield



Combined GPS Applications

- **Development of metrics for of combined civil applications (Forestry and Agriculture / Environmental Protection**



Forestry & Agriculture

MOP: Accuracy of pesticide application
MOE: Amount of pesticide used
MOO: Increase in crop yield

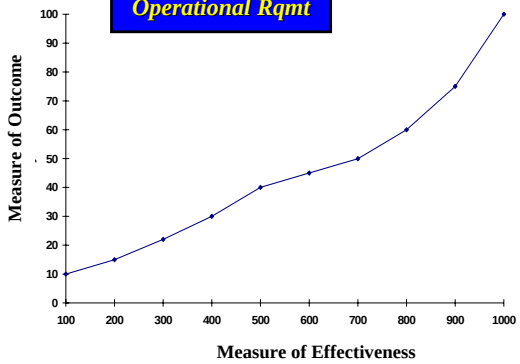
Environmental Studies

MOP: Accuracy of pesticide application
MOE: Amount of pesticide used
MOO: Decrease in pesticide in water table

Derive Metrics & Linkages

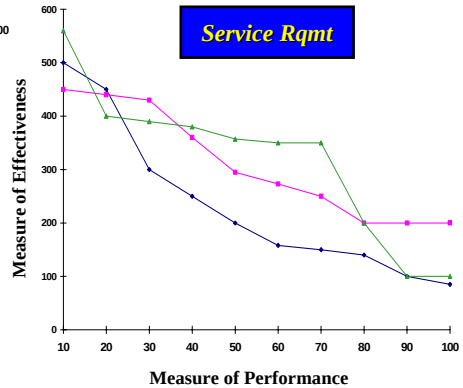
Develop metrics and links for each scenario

Operational Rqmt

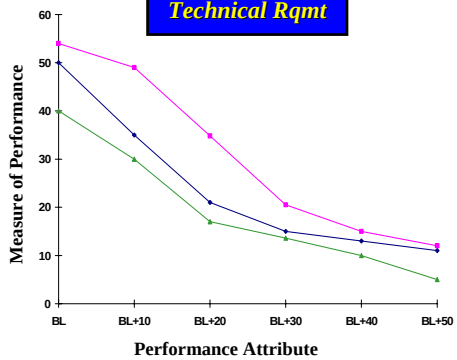


Measures of Effectiveness are related to Measures of Outcome by some function or rule set

Service Rqmt

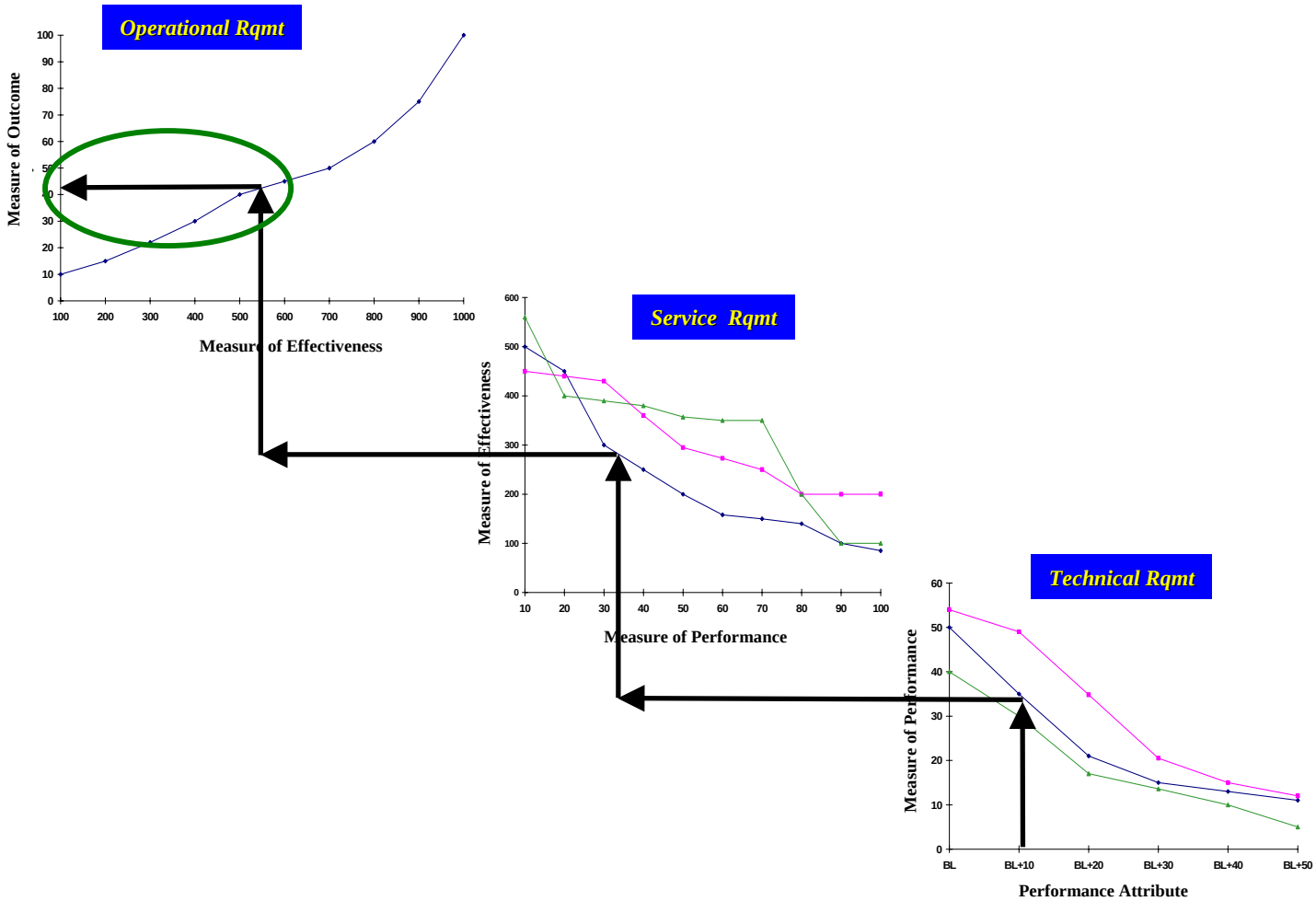


Technical Rqmt



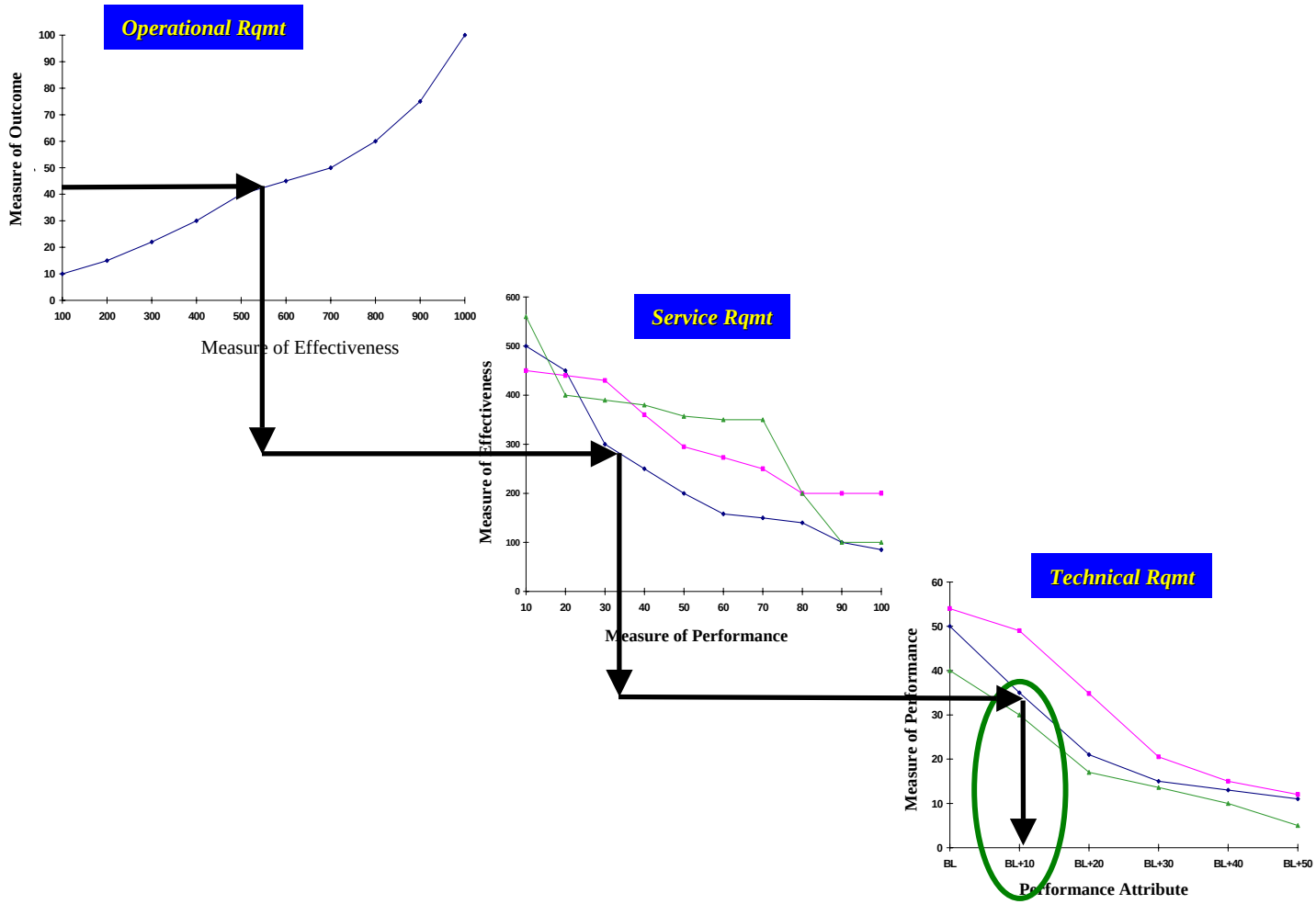
Derive Metrics & Linkages

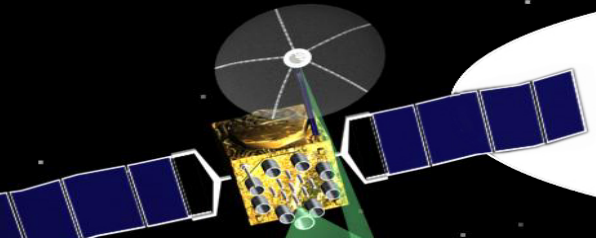
Recomposition provides utility assessment



Derive Metrics & Linkages

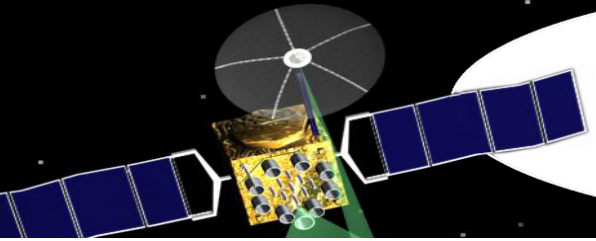
The attribute value will point to requirements





Advantages in Strategy to Task Methodology

- **Process already used for the Joint Program Office and APSPC / DRN to provide GPS III performance attribute value recommendations in support of the Draft System Specification (DSS) and the Capabilities Development Document (CDD)**
- **Although originally developed for military planning this method can also be used to analyze effects on civil / commercial GPS applications**
  - **Develop a civil / commercial decomposition**
  - **Show effects of GPS infrastructure beyond the warfighter**



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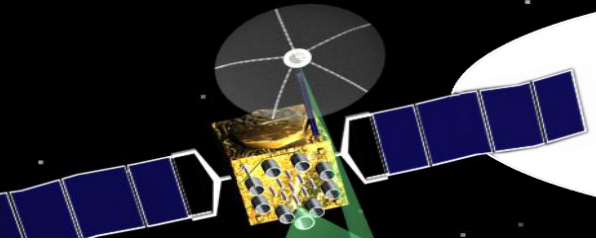

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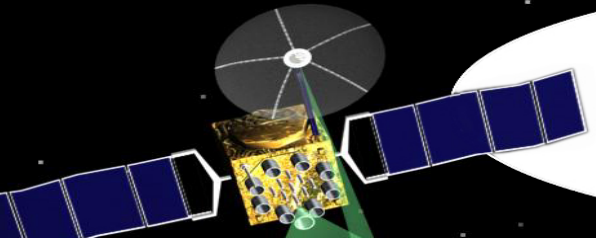
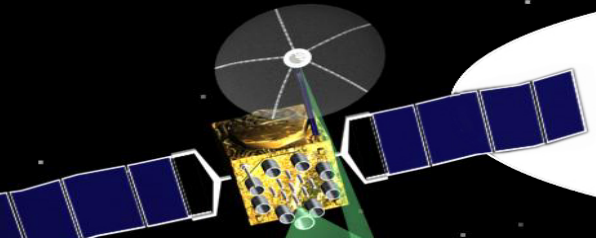


Scenario Analysis

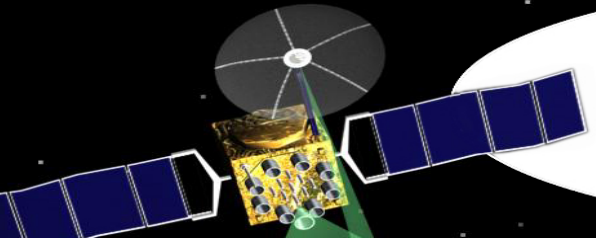
- **A parametric analysis to determine End User Accuracy Requirements was conducted on the following scenarios**
  - **Civil Aviation**
  - **Precision Agriculture**
  - **E911**
  - **National Park Rescue**
  - **HAZMAT Tracking**
  - **Positive Train Control**
  - **Construction and Survey**
  - **Harbor Navigation**
  - **Intelligent Highway**



PNT Systems Analysis

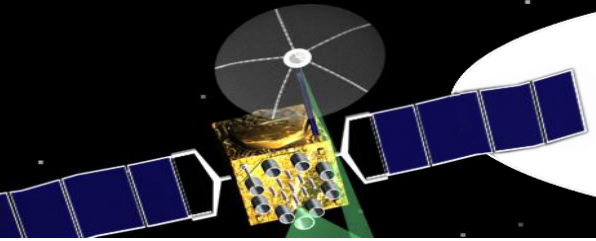
- **GPS baseline**
  - **L5 FOC (2014)**
    - **27 Block IIF in 6 planes**
    - **L1, L2, and L5 available**
- **Three GPS constellations**
  - **Baseline**
  - **Two GPSIII Variations**
    - **CDD Threshold vs. CDD Objective**
    - **All SVs now GPSIII (no mixed constellation)**
- **Augmentation systems**
  - **Wide Area Augmentation System (WAAS)**
    - **4 WAAS satellites**
  - **National Differential GPS (NDGPS) / High Accuracy NDGPS**
    - **NDGPS will use planned future Nationwide coverage**
  - **Global Differential GPS (GDGPS)**
  - **Assisted GPS (A-GPS)**
    - **Analyzed for E911 scenario only**

	No Aug	WAAS	NDGPS	GDGPS	A - GPS
Baseline GPS Constellation (27 IIF)					
GPS III Threshold					
GPS III Objective					



Effectiveness Analysis

- **Effectiveness analysis was conducted to capture the capabilities each architecture had on the requirements to successfully conduct each scenario**
- **End User Accuracy was evaluated in the following environments**
  - **Benign**
  - **Urban Canyon**
  - **Forest Canopy**



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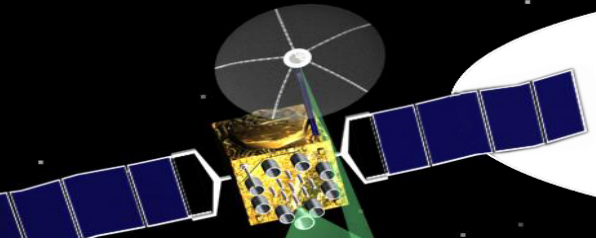
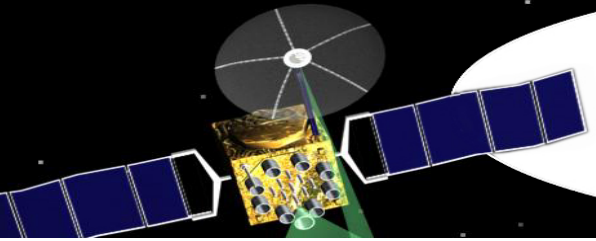


AoAs in Civil Community

- **Needed to educate civil community on the purpose / process of an AoA**
  - **An AoA was desired to match civil requirements process to military requirements process**
  - **Previous analysis not adequate for civil requirements**

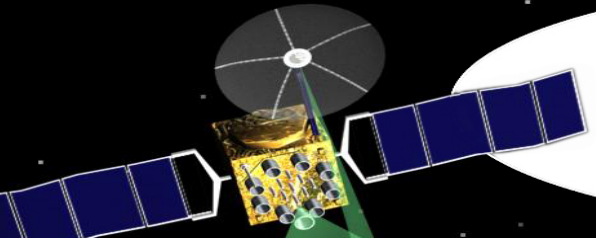
- **An AoA is conducted by the Department of Defense to make reliable, objective assessment of the available options for meeting mission needs**
  - An AoA is an analytical comparison of the operational effectiveness and cost of proposed materiel solutions to shortfalls in operational capability (these shortfalls are also known as mission needs).
  - AoAs document the rationale for identifying a preferred solution or solutions to the shortfalls.
  - AoAs are an important element of the defense acquisition process.
    - Air Force AoAs must not only make a case for having identified the most cost effective alternative, they must also make a compelling statement about the military utility of acquiring it.

*From AoA Handbook (Office of Aerospace Studies, AFMC OAS/DR)



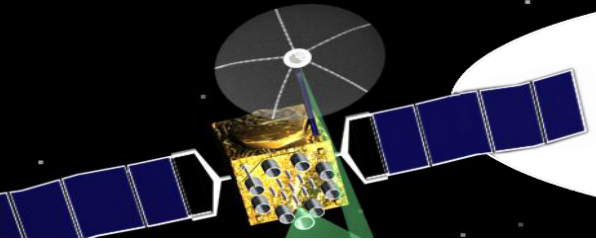
Civil Requirements Strategy

- **No documented overarching government strategy to define civil GPS requirements**
- **Utilizing strategy to task methodology, developed a decomposition of the various civil GPS application areas to define civil requirements.**
  - **Civil / commercial decomposition**
    - **Provides traceability from requirement to utility**
    - **Link effects of GPS infrastructure to the various civil GPS applications**



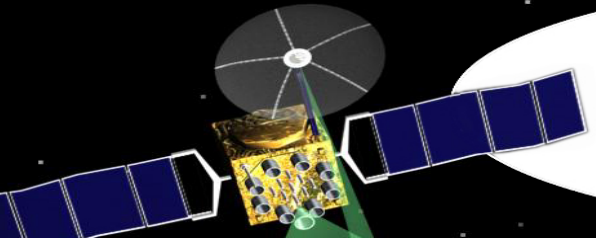
Political Concerns

- **Working with multiple government agencies resulted in political sensitivities**
  - **Each augmentation system owned by a different agency**
    - **Concerns how “their” augmentation system was represented**
  - **Scenarios resulting in “too much” benefit from GPS improvements**
    - **Concerns with “footing the bill”**



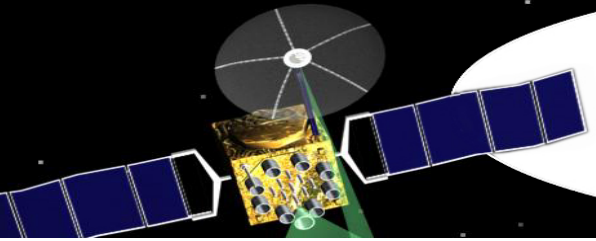
Subject Matter Expert

- **Relied heavily on Subject Matter Experts (SMEs) from several government agencies to help:**
  - **Identify resources**
    - **Identify previous studies**
    - **Identify possible models**
  - **Provide operational expertise**
    - **Develop realistic scenarios**
    - **Define sound operational practices**
    - **Identify measures of merit pertinent to the civil community**
      - **How do you measure success?**
- **Government SME not always available**
  - **Not readily identifiable across multiple government agencies**
  - **Study team director had no direct control to task SME**
  - **Often relied on non government expertise in industry and academia**



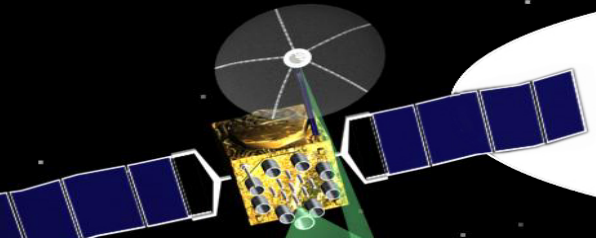
Alternatives

- **Multitude of GPS improvements and augmentation systems to study resulted in initial analysis being broad and shallow**
  - **GPS improvements**
    - **Space segment**
    - **Control segment**
    - **User segment**
  - **Augmentation / other systems**
    - **Wide Area Augmentation System (WAAS)**
    - **Local Area Augmentation System (LAAS)**
    - **National Differential GPS (NDGPS)**
    - **Continuously Operating Reference Stations (CORS)**
    - **International GPS Service (IGS)**
    - **Global Differential GPS (GDGPS)**
    - **Real Time Kinematic (RTK)**
    - **Assisted GPS (cell phone technology)**
    - **Other GPS like systems (GALILEO, GLONASS)**



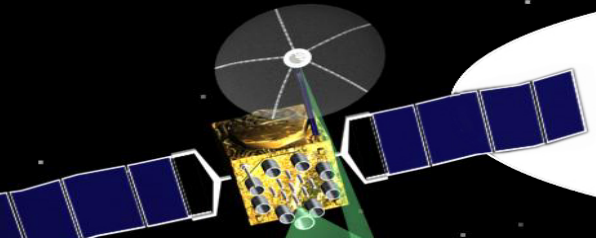
Effectiveness Analysis

- **Qualitative Integrity Analysis**
  - **GPS signal integrity is critical for many GPS applications involving safety of life issues**
    - **Augmentation systems were developed to meet integrity requirements for specific GPS applications**
    - **No standardized integrity definition across these diverse applications and supporting augmentation systems.**
    - **Without such a standardized definition the study team could not quantitatively compare the effects of integrity for the different augmentation systems (an apples to oranges comparison)**



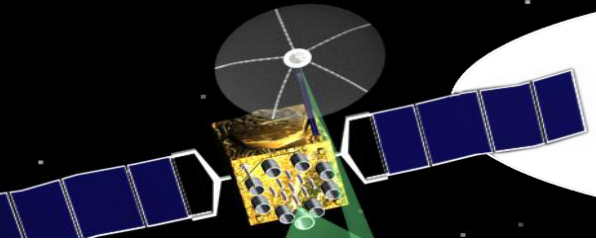
Cost Analysis

- **Extremely complex issue for this study**
  - **Typical AoA consists of large government cost analysis team**
    - **No such government team existed**
    - **Contractor team had limited capability to support cost analysis.**
  - **Required collecting cost data from several government agencies**
  - **Data was provided in a variety of formats**
    - **Inflation was built into some inputs, but not others**
    - **Applied inflation calculations to areas where inflation was not incorporated**
      - **Inflation Indices Training Briefing was used as a guideline for the application of inflation**
      - **Applied examples and formulas from this briefing along with the Military Inflation Indices table to build inflation into cost data that was provided to us in $CY**
      - **Converted $CY -> $TY**
    - **Standardized data for each alternative**
  - **Cost Estimates were reported for FY2006 – FY2028**
    - **Does not include money already invested (sunk costs)**
    - **Does not include User Equipment Costs**



Conclusions / Observations

- **This study provided a good initial cut at PNT requirements for the civil community**
  - **Broad look at multiple civil scenarios and a variety of GPS augmentation systems**
    - **Strategy to task decomposition for civil GPS applications**
    - **Highlighted areas requiring further study**
  - **Several challenges were overcome**



Contacts

Rick Bloser
(719) 622-2857
rick.bloser@gd-ais.com

Jeff Dubois
(937) 476-2566
jeff.dubois@gd-ais.com

Questions?